

# MONTHLY NOTICES

## OF THE

### ROYAL ASTRONOMICAL SOCIETY.

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No. 5.

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PROFESSOR ADAMS, F.R.S., President, in the Chair.

George Russell Rogerson, Esq., Waterloo, near Liverpool, and  
Richard Cross, Esq., Forest Hill,

were balloted for and duly elected Fellows of the Society.

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The following Resolution was passed at the last meeting of the Council:—

Resolved:—That all books belonging to the Society, now in the hands of Fellows, be returned to the Assistant-Secretary at Somerset House, on or before the 1st of May next, after which date, and until further notice, no book can be taken out of the Library without the express permission of the Library Committee.

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*Notes to accompany Chromolithographs from drawings of the planet  
Jupiter, made with the Six-foot Reflector at Parsonstown,  
in the years 1872 and 1873.*

(Communicated by the Earl of Rosse, F.R.S.)

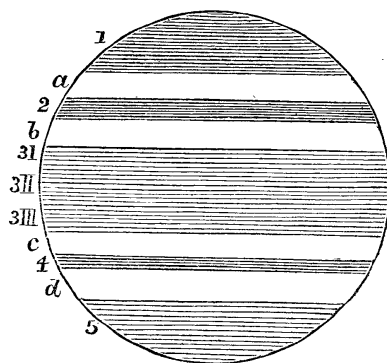
Much attention having been given of late to the appearance of the belts and other markings on *Jupiter*, more especially in regard to their colour, and the employment of the pencil having been facilitated by the application of a clock-movement to our Six-foot Reflector, we were induced last season to try how far the more delicate markings and tints on the planet's surface, which might

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be beyond the reach of smaller instruments could be brought out by a larger aperture. The disadvantage which the limited range\* of that instrument in right ascension entailed in the delineation and continuous study of the physical features of a rapidly revolving planet, together with the circumstance that more advantage is derived from increase of aperture in the examination of *fainter* objects, had been the cause of most, possibly too large a proportion, of our attention having been directed from the first to the Nebulæ. In the short space of time available, it was found impossible to do more than take hasty sketches at the telescope accompanied by notes of the colours and general appearance of the belts. From these sketches water-colour drawings, of which the accompanying lithographs are faithful copies, were made, generally on the following morning. To render each drawing as independent as possible of any preconceived bias, the colours were invariably mixed afresh, and in no case was a drawing compared with any of those already made until it was completely finished. The drawings have been executed by Dr. Copeland, usually observing alone. The whole of the notes are given as they were written down at the telescope. Although many of these may perhaps appear to be unnecessary, as only expressing in words what is given in the drawings, a careful comparison will show that there are many points of divergence between drawing and description, so that the one may be regarded as to some extent supplementing the other. There are also many nuances of colour and peculiarities of form represented so faintly that they might readily be overlooked or considered as accidental unless special attention was drawn to them. From the fact already mentioned, that each sketch was coloured without any reference to the others, it is scarcely to be wondered at that colours which are named alike in the notes, show widely different tints in the drawings.

To make the notes intelligible without the necessity of inserting letters or other marks in the drawings, the following nomenclature was adopted. The dark zones are marked 1, 2, 3, 4 and 5, as shown in the figure, and the bright ones *a*, *b*, *c* and *d*. In the case of the equatoreal zone, 3, the Roman numerals I, II and III, are appended to express subdivisions; in all cases the smaller numbers and earlier letters refer to the southern or upper part of the disk.

Unfortunately the drawings have not been arranged, as we had intended, in regular order of the rotation of *Jupiter*, owing to our having been misled by an error in



\* At most, 40 minutes for an object near the Equator.

Sir John Herschel's *Outlines* (Art. 512, p. 340, 8th edition), where the period of 9<sup>h</sup> 55<sup>m</sup> 50<sup>s</sup> mean time is marked sidereal time.

The error was only detected, after the lithographs had been struck off, on reading Dr. Schmidt's article in No. 1973 of the *Astronomische Nachrichten* and then referring to No. 1541 of that journal. The correct values of L, the Jovicentric longitude of the true centre of the planet's disk, are given below. After the correction the drawings gain much in interest from the possibility of tracing a brick-red marking through many revolutions. The zero of longitude or first meridian of *Jupiter* is that which *Jupiter* would have presented to the Earth at noon on December 31, 1872, had his geocentric longitude been the same as at the moment of the opposition of 1873. The time at which the light left *Jupiter* is also given for each observation.

Beer and Mädler's period of rotation, 9<sup>h</sup> 55<sup>m</sup> 26<sup>s</sup>.5324 mean time\*, has been used in calculating the values of L.

Arrangement of Sketches in order of the Rotation of Jupiter.

No.	Date (Greenwich mean time).		L.	Time when light left Jupiter.	
				h	m
9	1873	Apr. 1, 9 49	3°0	9	10·0
14	„	Apr. 11, 8 58	38·2	8	18·3
10	„	Mar. 13, 10 59	63·4	10	21·9
6	„	Feb. 7, 13 34	72·5	12	57·6
5	„	Jan. 26, 14 27	95·4	13	50·0
17	„	Mar. 11, 11 13	130·3	10	35·7
16	„	Feb. 27, 12 5	153·7	11	28·8
12†	„	Feb. 10, 13 21	156·7	12	44·3
8	„	Jan. 24, 14 36	159·1	13	58·5
19	„	Feb. 20, 12 36	197·3	11	59·9
15	„	Feb. 3, 13 52	200·1	13	15·1
7	1872	Dec. 31, 16 15	201·4	15	36·1
11	1873	Jan. 17, 15 11	205·1	14	33·9
18	„	Feb. 8, 13 30	220·6	12	53·2
13	„	Jan. 22, 14 44	222·8	14	7·1
3	„	Apr. 10, 9 12	256·1	8	32·4
2	„	Mar. 7, 11 33	259·9	10	56·3
1	„	Feb. 6, 13 38	284·4	13	2·0
4	„	Mar. 22, 10 21	316·0	9	42·7

The ratio—

Polar semidiameter= Eq. semidiameter × 0·927—  
was adopted from the *Nautical Almanac*, for the form of the

\* See *Beiträge zur physischen Kenntniss der himmlischen Körper im Sonnensysteme*, by Wilhelm Beer and Dr. J. H. Mädler. Weimar 1841.

† No. 12, the lithograph is wrongly dated January 22.

disk; the equatoreal diameter of the drawings is 50 millimètres.

The magnifying power most used was 414; but in disturbed states of the atmosphere a lower power of 281 or even 120 often gave better definition, with these however only 4 ft. 8 in. and 2 ft. respectively of the large mirror came into use.\* On rare occasions power 650 could be used with advantage.† As all markings on the surface of the planet when situated near the edge of the disk have always been noted by us as being excessively faint and dim, little attention was paid to any traces of phase, and no attempt has been made to delineate it.

*Notes on the Colours and general Appearance of the Belts.*

*Opposition of 1872.*

January 15, 1872, 12<sup>h</sup> 55<sup>m</sup> Greenwich mean time. 1 grey; a yellow patch at the northern end of the dark marking in 2; 3 yellow, there is also a narrow streak of yellow on the northern edge of 4; 5 bluish. The planet was at times wonderfully well defined with power 414.

February 7, 1872, 11<sup>h</sup> 12<sup>m</sup>  $\pm$  G.M.T. 1 of a very uniform grey tint; white patches on the margin of the yellow equatoreal belt; 4 of a purplish neutral tint. Sketch very hurried.

*Opposition of 1873.*

No. 7; December 31, 1872, 16<sup>h</sup> 15<sup>m</sup> G.M.T.  $L = 201^{\circ}4$ .

In 3 I and 3 III are dark clouds; there is a bright diagonal rift in 3 III, and a bright central area in 3 II. The tints noted are: 1 greyish; *a* white; 2 greyish; *b* very white; 3 yellowish red; 4 the darkest part of the disk, and lastly 5 of a pale ashy blue. The equatoreal belt is not nearly so red as it was in the spring of 1872. The central area of 3 II is about the brightest part of the disk. 5 is darker than 1. There is a streak of yellow along the northern edge of 4.

No. 11; January 17, 1873, 15<sup>h</sup> 11<sup>m</sup> G.M.T.  $L = 205^{\circ}1$ .

*b* is very white and breaks in upon the equatoreal belt near the following (right) side, forming a white gulf, following which is a yellowish brown patch; *c* is white. The equatoreal belt is not nearly so intensely coloured as it was last year, the centre being almost colourless—grey and white—but bounded north and south

\* It is assumed that the aperture of the pupil was  $\frac{1}{8}$  inch, probably too large an estimate in the case of so bright an object as *Jupiter*. On no occasion were diaphragms used to reduce the aperture of the telescope, nor indeed is any provision made for their application.

† Powers 650, 281, and 414 are achromatic positive eye-pieces; the two former by Mr. H. Grubb, the latter by the late Mr. Cooke; their performance is very good in all parts of the field.

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by more highly coloured regions. Sat. I as seen to emerge from behind the planet was of a deep yellow colour (shown in the drawing) and much fainter than the planet. There is a marked projection in the middle of the south side of the equatorial belt. Definition good for a few very short intervals, otherwise rather poor.

No. 13; January 22, 1873, 14<sup>h</sup> 44<sup>m</sup> G.M.T.  $L = 222^{\circ}8$ .

1 yellowish; a reddish or reddish-yellow patch on the following side of *b*; a number of large and small, very white spots in 3 II; the northern polar zone (5) of a very uniform slate-grey.

No. 8; January 24, 1873, 14<sup>h</sup> 36<sup>m</sup> G.M.T.  $L = 159^{\circ}1$ .

The sky very hazy, with definition in rare moments only. Nothing more than a rough and hurried sketch taken. The tints are, 1 yellowish; *a* white; *b* very white; *c* very white; 4 purplish and the darkest part of the disk, and lastly 5 of a bluish grey.

No. 5; January 26, 1873, 14<sup>h</sup> 27<sup>m</sup> G.M.T.  $L = 95^{\circ}4$ .

The large, black spot is the shadow of Satellite III. Definition mostly poor, but still the large oblique white patches on the equatorial belt are occasionally well seen. The darkest patch is a little south of III Sh. Belt 2 fades away on the following side; zone 5 is as usual bluish grey.

No. 15; February 3, 1873, 13<sup>h</sup> 52<sup>m</sup> G.M.T.  $L = 200^{\circ}1$ .

The preceding and following parts of 3 I are reddish, the former inclining to brown and the latter to a very red copper colour: large white clouds in 3 II, small ones and a rather long white streak in 3 III; northern pole bluish grey. The northern edge of 3 is very ragged. Definition occasionally good, otherwise very poor; the long, narrow, grey cloud seen very well repeatedly, as also the bend and shading of belt 2, but the equatorial spots are not so well defined as on other occasions. The Sat. III noted as being  $1\frac{1}{2}$  time the diameter of Sat. II.

No. 1; February 6, 1873, 13<sup>h</sup> 38<sup>m</sup> G.M.T.  $L = 284^{\circ}4$ .

1 yellowish with a whitish patch on the preceding side; *b* very white on the following, reddish yellow on the preceding side; *c* very white; 4 neutral tint—darkest part of the disk—bounded by a narrow, yellowish line on the north; 5 blue-grey. Powers 120, 281, and 414. The following features were noted as being remarkable: 1st, the *right-handed* inclination of the cloud crossing the Equator; 2nd, the immense reddish yellow area extending far to the south on the preceding side, and 3rd, the fact of belt 2 being, so to say, *forced up* into contact with 1. There is only the slightest separation (not shown in the lithograph) of the preceding part of the dark boundary of 1 from the rest, in the other

part 2 is completely connected with 1, which is decidedly yellow in contrast with the blue of 5. Belt 4 is much darker than usual, with the neutral tint of last year and the band of yellow on the north. The patches on 3 are of a pale brownish yellow.

No. 6; February 7, 1873, 13<sup>h</sup> 34<sup>m</sup> G.M.T.  $L = 72^{\circ}5$ .

Definition occasionally good; power 281. *b* very white; 3 yellowish with white patches; 5 greyish. The belt 2 is much darker than usual, being nearly the darkest part of the disk; its following end, which is bent towards the north and terminates before reaching the limb, is separated from the equatorial belt by a very white interval that seems to be composed of rounded cloudy masses. The south edge of 3 is formed of two fine parallel lines of dark cloud, the other markings being very irregular with large 'port-holes.'

No. 18; February 8, 1873, 13<sup>h</sup> 30<sup>m</sup> G.M.T.  $L = 220^{\circ}6$ .

A reddish yellow patch on the following side of *b*; the dark spot in 3 II is of a full blue colour, while the white spots are intensely white and bright. The middle of *b* is composed of white clouds; *d* very white; *c* also white, but not quite so much so as *d*; 5 bluish grey. 3 III exhibits a long line of very small white clouds. The driving clock very troublesome (owing to recent alterations), many clouds are also passing over, but between them the definition is remarkably good, and all the markings drawn are well seen. There is no mistake about the blue colour of the spot in 3 II, as it was repeatedly examined in all parts of the field of view. When the clouds pass over the planet it is at once evident that the centre of the disk is much brighter than the margin.

No. 12; February 10,\* 1873, 15<sup>h</sup> 21<sup>m</sup> G.M.T.  $L = 156^{\circ}7$ .

*b* very white; 3 I reddish brown, as also 3 III; large white patches on 3 II, the brightest of which, near the preceding side of the disk, is the brightest marking on the planet; 5 slate colour. Seen very well for a few seconds between clouds; the clouds never completely obscured the planet, so that as their increasing density obscured one part after another, the order of brilliancy of the various regions of the disk could be readily estimated. Tested in this way the north polar zone (5) would seem to be about the darkest part of the disk, for when the planet is nearly obscured that zone is much darker than any other region. The belt 4 disappears rather on account of its narrowness than its blackness, so that the depth of its shading cannot be compared with that of the broader belts by this method. The central part of the equatorial belt is on the whole very bright, but the spot already mentioned, on the preceding

\* The lithograph is wrongly dated January 22.

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side, is considerably the brightest part, remaining visible as a bright oval disk when the rest of the planet is nearly obscured.

No. 19; February 20, 1873, 12<sup>h</sup> 36<sup>m</sup> G.M.T.  $L = 197^{\circ}3$ .

*b* is composed of white clouds; there are also a number of larger and smaller white clouds on 3 II and 3 III; 3 I is reddish, and *d* very white; while 5 is noted as dingy; 4 is as usual the darkest part of the disk. Almost all the red colour is now confined to the southern part of the equatorial belt, the rest of which is much broken up; the dark marking well seen—not blue. A small dark object passed rapidly (almost instantaneously) across the planet from north—preceding to south—following (Query, a meteorite?).

No. 16; February 27, 1873, 12<sup>h</sup> 5<sup>m</sup> G.M.T.  $L = 153^{\circ}7$ .

The belt 2 is ragged on both edges, and has a number of very small white clouds on it; 3 I is reddish, with exceedingly small white clouds; 3 II and 3 III of a very faint yellow, with very white clouds, the black spot is the shadow of Sat. II; 4 is purplish, with a yellowish streak on the northern edge; 5 is bluish.

The dark lines on the equatorial belt are fully darker than 4. The south polar zone, which is about half the width of the northern one, is at times suspected to be rough on the edge. Definition only very rarely good. Powers 281 and 414.

No. 2; March 7, 1873, 11<sup>h</sup> 33<sup>m</sup> G.M.T.  $L = 259^{\circ}9$ .

*a* and *b* are very white, the following part of *b* is reddish; 3 II and 3 III show white patches.

No. 17; March 11, 1873, 11<sup>h</sup> 13<sup>m</sup> G.M.T.  $L = 130^{\circ}3$ .

1 very faint; 2 is composed of very white and very irregular clouds; 3 I is reddish and 3 III yellowish; on the preceding side of 3 is a large bluish grey marking; 5 greyish blue; 4 the darkest part of the disk. The north polar zone was not seen bluish at first, but on closer examination it is certainly not yellow. Definition rarely good; all the markings, except the two dark streaks, are very faint.

No. 10; March 13, 1873, 10<sup>h</sup> 59<sup>m</sup> G.M.T.  $L = 63^{\circ}4$ .

1 is very faint; in 2 there are two patches darker than the rest; *b* and the patches in 3 are very white, the following patch in 3 II being the brightest; 3 I is yellowish; in 3 there are two bluish spots, of which the following one is the darker; 4 is again the darkest part of the disk, and of a neutral tint. Definition rather good.

No. 4; March 22, 1873, 10<sup>h</sup> 21<sup>m</sup> G.M.T.  $L = 316^{\circ}0$ .

*a* very white; 1 yellowish; there is a reddish spot on the preceding side of 2 and *b*; an excessively white patch in 3 II, also a dark blue spot in the same zone; 4 is as usual neutral tint; *d* very white, and 5 bluish. Definition pretty good, with powers 281 and 414.

No. 9; April 1, 1873, 9<sup>h</sup> 49<sup>m</sup> G.M.T.  $L = 3^{\circ}0$ .

Belt 2 is plainly interrupted; there is a reddish streak in 3 I, as also a dark streak certainly visible in *c*; belt 4 is very narrow.

No. 3; April 10, 1873, 9<sup>h</sup> 12<sup>m</sup> G.M.T.  $L = 256^{\circ}1$ .

*b* is very white, with a reddish patch on the following side; the patches in 3 I are very white; 4 is the darkest part of the disk—neutral tint; there is a blue patch in 3 II, and one of a darker blue tinge in 3 III; 5 is bluish grey. Definition very good, with powers 281 and 414. The inclined streak with its bend is very well shown. The red patch in *b* seems to break off abruptly on the following side. There is a narrow band of red on the northern edge of 3. The irregularities in 2 are very well seen; 4 is very narrow, and thought to be bordered with red. The inclined belt and the southern edge of 3 are composed of parallel dark streaks, as shown in a drawing previously made (compare No. 13, January 22).

No. 14; April 11, 1873, 8<sup>h</sup> 58<sup>m</sup> G.M.T.  $L = 38^{\circ}2$ .

2 of a purplish or dark neutral tint; *a*, *b*, 3 I, parts of 3 II and 3 III, as also *c* and *d*, are white; the dark cloud in 3 III is bluish, 4 is purplish, and 5 bluish grey. Definition at times almost perfect, with powers 281, 414, and 650.

Before attempting to deduce any results from the foregoing observations, it may be well to say a few words about two published sets of drawings of *Jupiter* made contemporaneously with our own. The first of these is contained in "Observations de *Jupiter* et de *Mars* faites à Louvain pendant l'opposition de ces planètes en 1873; par M. F. Terby, docteur en sciences.—Extrait des *Bulletins de l'Académie royale de Belgique*, 2me série, tome xxxvi., No. 11, 1873." There are 14 drawings of *Jupiter*, made with a telescope of 9 centimètres ( $3\frac{1}{2}$  in.) aperture, and powers 120, 186, and 240. Assuming the dates given to be Louvain mean time, we have reduced them to Greenwich mean time, using 18<sup>m</sup>·8 for the difference of meridians, and have calculated the values of  $L$  to facilitate comparison.

M. Terby's No.	Greenwich M.T.	$L$ .		Time when light left <i>Jupiter</i> .	
		h	m	h	m
T 1	1873, Jan. 23, 10	6·2	205·4	9	29·1
" 2	" Feb. 28, 8	3·7	158·3	7	27·1
" 3	" Mar. 8, 6	23·7	223·4	5	46·7

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M. Terby's No.	Greenwich M.T.	L.	Time when light left Jupiter.
	<sup>h</sup> <sup>m</sup>	<sup>o</sup>	<sup>h</sup> <sup>m</sup>
T 4	1873, Mar. 8, 8 3.7	283.9	7 26.7
" 5	" " 23, 6 21.2	321.8	5 43.1
" 6	" " 24, 8 6.2	175.9	7 28.0
" 7	" " 25, 6 26.2	266.0	5 47.9
" 8	" " 25, 7 58.7	322.0	7 20.4
" 9	" " 26, 7 48.7	106.6	7 10.3
" 10	" " 27, 7 56.2	261.8	7 17.7
" 11	" " 31, 7 38.7	133.7	6 59.9
" 12	" Apr. 1, 6 16.2	234.4	5 37.3

Nos. 13 and 14 we have omitted, as they only profess to represent the transit of the 4th Satellite.

The other set of drawings are those published by Mr. Knobel, in *Monthly Notices*, vol. xxxiii. p. 474; these are three in number, for which we find the following quantities:

Mr. Knobel's No.	Greenwich M.T.	L.	Time when light left Jupiter.
	<sup>h</sup> <sup>m</sup>	<sup>o</sup>	<sup>h</sup> <sup>m</sup>
K 1	1873, Mar. 26, 7 50	107.4	7 11.6
" 2	" Apr. 20, 7 30	259.7	6 48.9
" 3	" May. 11, 8 15	207.3	7 31.2

The drawings were made with a silver-on-glass reflector of  $8\frac{1}{2}$ -in. aperture, and a power of 208.

Of all the features presented to our view by *Jupiter* during the opposition of 1873, probably the most remarkable is the great break in the southern side of the equatoreal belt in  $L=260^\circ$ . It is shown in Nos. 2, 3, 7, 11, 13, 15, and 18, it occurs most unmistakeably in K 2 and 3, and is also indicated by the markings in T 3 and 4, and perhaps to some extent also in T 7, 10, and 12. On December 31, 1872 (No. 7), it would seem that the break had either not fully occurred, or that it was very imperfectly seen, being  $35^\circ$  following the centre of *Jupiter's* disk; on January 17, 1873, it was fairly seen. On January 22 and April 10 (Nos. 13 and 3), it was seen to great advantage under most favourable circumstances; on both these days the preceding part of the southern edge of the equatoreal belt consisted of two parallel lines of dark objects (clouds?) separated by a clearer interval, but with this remarkable difference, that whereas on the former occasion both lines were curved towards the Equator at their following ends, on the latter, only the southern one was so curved, thus causing it to coalesce with, and possibly to intersect the other. This union appears to have been very permanent, for it was well seen by Mr. Knobel on April 20 and May 11. Following and filling up this break is a brick-red area, that was seen most fully on February 6 (No. 1), the chromolithograph for which day is, however, too faintly tinted. The red region may extend

some  $30^{\circ}$  in longitude, reaching from  $L250^{\circ}$  to  $L280^{\circ}$ : its following end is just seen in sketch 4.

Since the break in the edge of the equatoreal belt is indicated by the following end of the long, curved marking in our earliest drawing, and is fully shown by the intersection of the dark belts in Mr. Knobel's latest drawing, and was depicted with more or less certainty on eight other occasions, there seemed to be a chance of determining the period of rotation from it with some considerable accuracy. Taking therefore the Parsonstown Sketches 2, 3, 7, 11, 13, 15 and 18, also K 2, K 3, and T 3; further, using the times when the light left *Jupiter* on each occasion (as a means of correcting for the varying distance of the planet), also allowing *in time* for the distance of the point selected for observation from the centre of the planet's apparent disk, and lastly making a still further small time-allowance for phase, the following summary was arrived at:—

Corrected time when the point was at the true centre of the planet's disk.				Rotations elapsed.
1873. G.M.T.				
d	h	m		
0	16	34.7		0
17	15	23.8		41
22	15	5.0		53
34	14	44.9		82
39	14	23.0		94
66	11	0.4		159
T 3 . . . . .	67	5	43.1	161
	100	8	45.8	241
K 2 . . . . .	110	7	25.6	265
K 3 . . . . .	131	8	41.7	316

Putting then  $t$  = the error, in minutes of time, of the first observation, and  $\Delta R$  = error of Mädler's period, and combining the first observation with each of the others in succession, we have the following equations of condition:—

$$\begin{aligned}
 0 &= -4.0 + t + 41 \Delta R \\
 0 &= +31.9 + t + 53 \Delta R \\
 0 &= +23.9 + t + 82 \Delta R \\
 0 &= +56.7 + t + 94 \Delta R \\
 0 &= +30.4 + t + 159 \Delta R \\
 0 &= -37.8 + t + 161 \Delta R \\
 0 &= +29.5 + t + 241 \Delta R \\
 0 &= +58.7 + t + 265 \Delta R \\
 0 &= +7.3 + t + 316 \Delta R
 \end{aligned}$$

The complete solution of these equations gives  $t = -18^m.44$

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+ 14<sup>m</sup>.15;  $\Delta R = -0^m.02172 \pm 0^m.07758$  and the probable error,  $r$ , of a single observation =  $\pm 21^m.65$ . Substituting the values of  $t$  and  $\Delta R$  in the equations, we have the outstanding errors shown in column  $\alpha$  of the following table:—

$\alpha$ m	$\beta$ m	$\gamma$ m
-23.3	-30.4	-27.2
+12.3	+5.2	+7.8
+3.7	-3.5	-2.1
+36.2	+29.0	+29.8
+8.5	+1.0	-0.9
-59.7		
+5.8	-1.9	-7.4
+34.5	+26.7	
-18.0	-26.0	

The large outstanding error for the Louvain observation would seem almost certainly to arise from the time of M. Terby's No. 3 being given 1<sup>h</sup> too early; the correctness of this surmise is rendered almost certain by the fact that the preceding curved marking in his No. 4, made on the same evening, agrees almost exactly with our selected point, and can only be reconciled with T 3 by assuming an error in the time of the latter to the extent mentioned. Under these circumstances, the Louvain observation was omitted, and the remaining 8 equations being solved again, we obtained

$$t = -25^m.35 \pm 10^m.31, \Delta R = -0^m.02527 \pm 0^m.05578, \\ r = \pm 15^m.57.$$

The outstanding errors are given above in column  $\beta$ .

As a further experiment, the Parsonstown observations were used alone; they gave

$$t = -20^m.43 \pm 10^m.97, \Delta R = -0^m.06836 \pm 0^m.08553, \\ r = \pm 14^m.12$$

with the outstanding errors given in column  $\gamma$ .

Figures 10 (March 13) and 14 (April 11) present two features in common, these are the markings in the north part of the equatoreal zone. Taking the centre of the preceding marking, and allowing for aberration and phase, we have the times when it was at the centre of the disk, reckoning from January 0, 1873, 72<sup>d</sup> 9<sup>h</sup> 44<sup>m</sup>.4 and 101<sup>d</sup> 7<sup>h</sup> 58<sup>m</sup>.8, 70 rotations having intervened. Hence the period is 9<sup>h</sup> 55<sup>m</sup> 3<sup>s</sup>.8.

In the same way the preceding end of the following spot occupied the true centre of the planet's disk at 72<sup>d</sup> 10<sup>h</sup> 29<sup>m</sup>.1 and 101<sup>d</sup> 8<sup>h</sup> 33<sup>m</sup>.9, giving a period of rotation = 9<sup>h</sup> 54<sup>m</sup> 55<sup>s</sup>.4. Taking Schmidt's velocity of rotation of the equator of *Jupiter*\* at 40211

\* *Astronomische Nachrichten*, No. 1973.

Paris feet per second, which agrees exactly with Mädler's period, we have for the proper motions of the spots,  $+ 25.6$  Paris feet and  $+ 35.1$  ft. per second (or 17 and 23 statute miles per hour), both with a probable error of  $\pm 13.6$  ft. The probable error is obtained from the result already arrived at, that the interval of time between two of our drawings, as deduced from the original sketches, has a probable error of  $\pm 14^m.12$ . It is well known that results of far greater accuracy may be obtained by noting the exact time when any particular marking passes the centre of the disk, but the limited range of our instrument almost entirely precludes the use of this method.

In fig. 19 there is a dark marking in the equatorial belt that may be recognised in M. Terby's No. 6. A complete reduction of these observations gives  $31^d 19^h 8^m.2 = 77$  rotations, for the interval elapsed: whence it follows that the spot had a proper motion of  $+ 53.5$  Paris ft.  $+ 12.7$  ft. per second, or  $+ 36.9$  miles per hour.

Schmidt, in *Ast. Nach.* No. 1973, gives a number of cases of proper motion of spots on *Jupiter*, ranging from 10 ft. to 297 ft. per second.

The aspect of the planet given in fig. 16, February 27, will be found represented with as close accordance as can be expected, considering the difference of the instruments used, in M. Terby's No. 2, which was taken two rotations later. The curved marking called  $\alpha$  by M. Terby can be immediately identified in the Birr drawing; but it would seem to be hardly possible that it is identical with either of those marked with the same letter in his Nos. 9 and 11, but rather that all three markings are entirely distinct. The  $\alpha$  of M. Terby's Nos. 2 and 11 are *both* shown in our fig. 16.

The blue spot seen March 22 (fig. 4) does not seem to have been very permanent, unless indeed it is shown near the following limb of fig. 1. It was figured by M. Terby once on March 23, and twice on March 25. Unfortunately this side of the planet has been little observed by us, and M. Terby's drawings were made too close to our's in point of time to allow of any deductions being made.

It may not be uninteresting to remark, that Mr. Knobel's No. 1 and M. Terby's No. 9 were taken at almost the same moment.

The nights, January 22, April 10 and 11, 1873 (Nos. 13, 3 and 14) far exceeded most of the others in point of definition; the last night in particular affording almost uninterrupted views of the most delicate markings. It will be readily understood that the definition with a six-foot aperture is, even on the best nights, more or less fitful; often for minutes together all the finer details of a brilliant object like *Jupiter* are mixed up in inextricable confusion, and it is only at more or less widely separated intervals that the confused image suddenly appears to freeze or crystallise into one of great sharpness. It is only in

such moments that details like the small white clouds in I 3 of No. 16 (not particularly well seen in the chromolithograph), or the small dark streaks shown in Nos. 3, 13 and 14 can be seen at all. It seems probable that the latter markings are closely related to those described by Secchi, in the *Memorie del nuovo Osservatorio del Collegio Romano*, 1852-1855, p. 114, with this difference, that what he describes as "a great multitude of bright lines on the obscure part beneath the principal band,"\* we have always seen as a number of fine dark lines on a bright ground.

Similar appearances are mentioned by Mr. Webb † as having been described by Schwabe and Jacob, but nothing of the kind is shown in the well-known magnificent drawings by Mr. De La Rue and Professor Piazzi Smyth.

The great loss of colour sustained by the equatoreal belt within the last two years has been a subject of general remark: its extent will be best seen by comparing the two rough drawings of the opposition of 1872 with the others. The redness of that belt in the autumn of 1870 was such that, according to a naked-eye observation by one of us in September of that year, the general colour of the planet's light was affected by it. This observation was made without a previous knowledge of the fact that *Jupiter's* belts were at all redder than usual.

It is very remarkable that while the southern and equatoreal regions of *Jupiter* during the opposition of 1873 were subject to such great changes, the northern regions, and especially the dark belt 4, remained so long unaltered. There is, however, now an end to this state of things, for, on February 22, 1874, 14<sup>h</sup> 37<sup>m</sup> G.M.T. the planet was seen without a trace of the northern temperate belt: the equatoreal belt was fawn coloured as in fig. 7.

\* "... una gran moltitudine di linee chiare nella parte oscura sotto la fascia principale."

† *Celestial Objects for Common Telescopes*, 2nd edition, p. 127.

### *On Two Ancient Conjunctions of Mars and Jupiter.*

By the Rev. Samuel J. Johnson.

As a supplement to the ancient Conjunctions referred to in the *Monthly Notices* for January, two important ones may be found in Street's *Astronomia Carolina* (1661), which I have not found mentioned by any more recent authors, and they, perhaps, merit further examination. Street gives the results obtained from the tables of his day. He states:

"Anno Christi 498. May the 1st day, near 7<sup>h</sup> reduced to London, ♄ was seen so conjoined with ♃, that there was no